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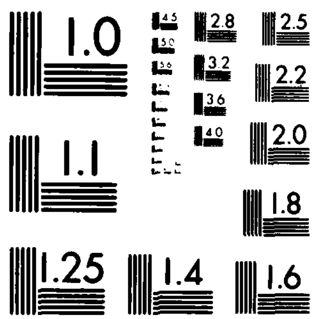

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Report on the Navy Life Cycle Cost Model for the SEA NYMPH Project

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Preface

This document was prepared under NUSC Project No. C55031, SEA NYMPH ILS/LCC, Principal Investigator, H. Knust (Code 343). The sponsoring activity is the Naval Electronic Systems Command, REWSON Systems Project Office.

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The NAVMAT LCC FLEX 9D cost modeling program is applied to a NAVELEX concurrent development in order to forecase costs for all affected Naval organizations and to isolate cost drivers expected to emerge during the operational phase of the life cycle.

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REPORT ON THE NAVY LIFE CYCLE COST MODEL FOR THE SEA NYMPH PROJECT

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REPORT ON THE NAVY LIFE CYCLE COST MODEL FOR THE SEA NYMPH PROJECT

INTRODUCTION

The effective management of the SEA NYMPH Project requires a means of defining, recording, evaluating and updating financial outlays that will be required by the Government for each fiscal year. The data should reflect requirements of both the acquisition project office and the other activities within the Navy that are affected by the introduction, use, and life cycle support of the SEA NYMPH (AN/WLQ-4) system. The cost data should be organized and processed in an efficient manner. It should be in a format that is compatible with the needs of the project office and other offices having financial responsibility. The data should be retained in historical form for the benefit of future acquisition projects and should lend itself to analysis. These requirements provide a basis for the use of automated data processing to create a useful financial planning document.

The Naval Electronic Systems Command Acquisition Manager for the SEA NYMPH Project, NAVELEX PME107-1, determined that the appropriate means for satisfying financial data requirements, as well as the more recent Navy instructions regarding fiscal plans, was a computerized model of the SEA NYMPH life cycle costs. The project manager decided a model of all anticipated Navy expenses would keep budget items from "falling through the cracks," a constant concern on a concurrent program such as SEA NYMPH. A suitable computer program for an in-house Navy cost model has been developed for Navy equipment acquisition programs under the sponsorship of the Chief of Naval Material (CNM). The Naval Weapons Engineering Support Activity, Washington Navy Yard, has been responsible for the development of these computer programs.

A previous report, entitled <u>SEA NYMPH Pilot LCC Model Development</u>, TD 5699, Sept 1977, presented the initial application of these cost model programs to the SEA NYMPH Project. This report is a record of the evolution from a pilot model to a mature model that is now becoming the basis for projecting costs on other equipment acquisition projects. This report addresses how the cost model reports have evolved, some practical questions such as the level of management using cost models, data formats useful to the management, and a sequence of steps through which a cost model can be organized for the NAVMAT LCC FLEX Computer Program.

COST MODEL BACKGROUND

ORIGINS

The concepts of life cycle cost (LCC) came into the Department of Defense from the aircraft industry, where cost optimizing techniques evolved as part of the competitive effort to sell commercial and military aircraft. For a number of years, the sole user of LCC techniques within the Navy was the Naval Air Systems Command.

Interest in the use of life cycle cost models and cost analysis was given substantial impetus by OMB Circular A-109, Major System Acquisitions; which was released by the Office of Management and Budget in April,1976. Section 7 of that document stresses the need to ensure that each major system justifies the allocation of the Nation's limited financial resources. Circular A-109 requires a systematic tradeoff of the costs and expected performance. It provides for measurement of actual costs against predicted costs and for the monitoring of costs through the development, acquisition, and operational phases of an equipment's life cycle.

The response of the Department of Defense to A-109 appeared in January 1977 in the form of updates to DOD Directives 5000.1: Major System Acquisitions, and 5000.2: Major System Acquisition Procedures. In particular, the revised 5000.2 directive includes a requirement for a Mission Element Need Statement (MENS). Section IV of the MENS format requires life cycle cost analysis for cost savings opportunities. Section V requires life cycle cost analysis to establish affordability in relationship to the overall Service budget. The combination of A-109 and the revised DOD instructions have served to spread involvement in LCC across all Department of Defense acquisition activities.

The SEA NYMPH Project developed within the same time-frame as the A-109 promulgation and the resultant changes to the DOD acquisition directives. Although SEA NYMPH predates the active imposition of these requirements, the usefulness of LCC to the project manager and the importance of the SEA NYMPH Project made it an obvious candidate for the introduction of LCC modelling into the Naval Electronic Systems Command.

The development of a SEA NYMPH Life Cycle Cost Model was added to an existing ILS task for SEA NYMPH at the Naval Underwater Systems Center, New London. A companion task for this development was given to Naval Weapons Engineering Support Activity,

Washington Naval Shipyard. This arrangement combined the NUSC expertise for submarine electronic equipment development with the Naval Weapons Engineering Support Activity expertise in the development of life cycle cost models. The initial product was a pilot model based upon the LCC MOD 1B Program. This program utilized a fixed cost breakdown structure containing 89 lines of information. The program utilized 98 cost factors for the calculations. This was found quite rapidly to be inadequate. The costs did not always fit the cost structure of the model. A second generation cost program, known as LCC FLEX 4B, was introduced. This allowed some additional lines of cost data and had partial flexibility as to the selection of titles for cost line items. However, the evolution of SEA NYMPH rapidly overwhelmed the FLEX 4B ability to accurately reflect what was going on with the necessary detail. For example, the SEA NYMPH LCC Report for January 1978 had a single line entry for hardware acquisition and a 15-year life cycle. By July of 1978, the hardware data had been divided into 9 line items, each with its own acquisition schedule, and the life cycle had been expanded to 22 years.

In response to what was being experienced by SEA NYMPH and other projects that were using the LCC FLEX 4B, the Naval Weapons Engineering Support Activity developed a third generation life cycle cost program known as LCC FLEX 9. This program features a cost breakdown structure in which nothing is fixed. In the FLEX 4B, half of the structure had been fixed. In the original MOD 1B, all line items had been fixed. The completely variable cost breakdown structure provided the flexibility needed. In July 1978, with the LCC FLEX 9 applied to the still-growing SEA NYMPH Project, the number of lines of cost data had expanded from 89 to 276. The number of cost factors had increased from 98 to 295. Figure 1 summarizes how the size of the model has changed with time.

Cost Model in Use	Date	Lines of Cost Data	Number of Cost Factors
MOD 1B	Sep77	89	98
FLEX 4B	Jan78	89	101
FLEX 9D	Jul78	276	295
FLEX 9D	Apr79	283	292
FLEX 9D	May80	228	238
FLEX 9D	Oct80	251	253

Figure 1. SEA NYMPH Cost Model Size

In regard to the variation in the size of the cost model, it should be noted that the limits on the LCC FLEX 9D Program are

300 lines of data and 300 cost factors. An effort was made in the Spring of 1980 to streamline the model. This created space for expanding another portion of the model, where more budgetary detail was needed

APPLICATION

Cost models may be described as having two general types of application; one being parametric and the other being budgetary. A parametric cost model employs cost values that may be based on an historical data base from other systems, or values that have been derived by hypothetical mathematical analysis. Parametric cost models are used to gain a rapid assessment of what a proposed equipment will cost to build, operate, and maintain. Parametric cost models are useful to industry in preparing responses to the invitations by the Government for new development proposals. In such responses, time is of the essence and each company must make critical decisions in a hurry. The intention of parametric modeling is to identify relative magnitudes of cost; using these data to disqualify proposal alternatives that generate cost extremes. This allows the company to concentrate on those proposal alternatives that have the best chance of producing a winner.

The second general type of cost model application is more budgetary in nature. It is concerned with far greater detail than the parametric. This detail involves both the financial planning aspect and the cost optimization of whatever parametric proposal was accepted. A budgetary cost model generated by the contractor may represent a contract proposal. It is, however, a subset of a much larger model representing all of the costs the Government must bear across the entire life cycle. A contractor may develop and produce an equipment over a span of 10 years; the Government was paying to plan the equipment 5 years before production and may still be paying to operate and maintain the equipment 10 years after the production line closes down. It is important to make this distinction when specifying the costs that a contractor is to report in a design-to-cost/life cycle cost model.

A Navy life cycle cost model is an optimized budgetary portrayal of what is to be spent; beginning with the in-house concept definition work and carrying through the development,the production,the operation,the overhauls and updates,to the point of discard some 20 to 30 years later. The Navy life cycle cost model for a new equipment embraces all the costs of all Naval Activities affected. It should be noted that a cost model for a new equipment may also be a subset of yet a larger model for a new platform that will use the equipment, such as the Trident submarine.

There is a relationship between the cost breakdown structure (CBS) in a cost model and contract work breakdown structures (WBS). If laid out properly in the beginning, these two structures can complement each other nicely through development and production. The WBS defines the tasks that have to be done and the corresponding CBS projects the funding required for each year.

A budgetary cost model is, in effect, a plan to spend money; and as such the amounts of money within a given year become more and more rigid as that fiscal year approaches and then passes into history. The funds in the next five fiscal years of a Navy life cycle cost model should represent the actual budgetary submissions within the Department of the Navy. Thus, it can be seen that the intention of such a model is quite removed from the rough-order-of-magnitude costs in a parametric model.

The life cycle costing process, in its application to the SEA NYMPH Project, has emphasized the budgetary aspects of cost modeling. The Acquisition Manager desired that the existing budget plans be organized into a cost model document that would provide a long-term projection for all related Navy funding requirements. This application is different in that the emphasis was shifted away from the theoretical optimization of cost by engineers and cost analyists. The idea was to make a cost model that is workable by project managers.

Much thought has gone into finding ways of tailoring the cost data away from complex technical formats towards something that would give the project manager the essentials without overwhelming detail. The manager must be able to digest the information and communicate in his own way with the funding resource sponsor in the Pentagon. If questions arise at higher echelons, the manager needs to be able to find how the cost data were derived and to find this information rapidly. This has not been easy; because the LCC FLEX 9D, like the other LCC programs, is oriented towards data forms that a technical analyst would use. Changing the report formats involves nothing short of reworking the FLEX 9D Program. Two innovations resolved these difficulties:

a. A cost model book has been organized for use by the project management office. The book contains the latest computer runs, the latest data inputs, and a section composed of separate derivation sheets for each line of cost data. The contents of the SEA NYMPH Cost Model Book are described in Appendix B.

b. Hybrid report formats have been developed using a word processor. These formats bridge the gap between the cost analyst reports generated by the LCC FLEX 9D Program and the budget sheets that project managers submit to the Pentagon, through the Chief of Naval Material, utilizing NAVMAT Form 7110.1, which is known

as the P-1 Item Nomenclature Sheet. The hybrid format uses the P-1 sheet headings and then lists the funding requirements in terms of each line item in the cost model. The format has been used for the POM-83 O&MN and OPN funding. See Appendix C for more details.

The word processor introduces a new dimension of flexibility into the LCC FLEX 9D cost model. There is no limitation on the variety of report format that a word processor can generate; whereas a change to the report generated by the LCC FLEX 9D Program means changing code in the computer program itself. The word processor is an inexpensive solution that allows tech data from the cost model reports to be translated into a format the user is familiar with. For the project manager, it is the P-1 sheet; but for another user the format might be oriented towards transportation, farm machinery, etc.

The point here is the need for communication of cost data in the working language of the user. The user probably does not know life cycle cost details and does not have the time to decipher volumes of computer reports. The data needs to be tailored to his needs in such a way that he can go into deeper detail by himself without assistance. The hybrid form should give the user sufficient information keyed to his own working circumstances, so that he can figure out for himself where to look in the cost model for more detail.

The principal responsibility for managing the life cycle cost effort for SEA NYMPH was assigned to the Project Financial Manager. It was the Manager's task to interface with the Naval Underwater Systems Center and the Naval Weapons Engineering Support Activity to collect the budgetary data and the project planning data necessary to construct an accurate projection of what was going to happen. This interface also extended upwards in the command chain to the funding resource sponsors at the Pentagon level. Interfaces were established with other Naval Activities. Figure 2 shows the funding flow through various Activities associated with the Project.

In the working relationships that evolved, NUSC became the designer of the cost model structure and worked with the project office in developing the LCC report formats to be submitted. NUSC passed this information, as well as cost data to the Naval Weapons Engineering Support Activity, which would modify the programming to meet the requirements and generate the LCC reports. A change in these arrangements occurred in 1979 when the Naval Electronic Systems Engineering Center, San Diego, assumed responsibility for the computer support function.

The SEA NYMPH Life Cycle Cost Model represented a major task that was new to both the Project Office and NUSC. On the other hand, the Naval Weapons Engineering Support Activity was thoroughly familiar with cost models, but not the type of equipment NAVELEX was building for submarines. After the cost model had been prepared, it was determined that an independent professional viewpoint should be introduced. The cost model was reviewed in November 1978 by Dr. Ben Blanchard, Director of Engineering Extension, Virginia Polytechnic Institute and State University as well as by Mr. M.R. Seldon, Life Cycle Cost Manager, General Dynamics Corporation, Pomona Division. Some important additions resulted.

As the development and early production contracts are completed, the final cost data are being used to update the earlier years in the model; so that they reflect where the money was spent,and how much. This introduces an historical aspect to the Cost Model that will be useful for future acquisition programs.

Although the main thrust of the life cycle cost task for the SEA NYMPH Project has focused on organizing a workable Navy-level life cycle cost model for project management, some interesting work has also been done in the cost analysis area. The LCC FLEX 9D Program is not limited to organizing thru-put budget data and adding the appropriate amount of inflation for each year. Particular interest has been directed at the depot level repair costs for the repairables turned in by the Fleet. Some of the results have the potential of generating some hardware design changes; based on the long term repair cost savings.

The SEA NYMPH model has been used by the Project Office to satisfy requirements for Provisional Service Approval. This involved promulgating the cost model to other affected Naval Activities for review and certification of the adequacy of the funding that the Model projected for future years. The model has been used as one of the supporting documents for the NAVMAT Logistic Review Group audit.The model has also been used in the preparation of the POM-82 and POM-83 budgets.

USE OF CONTRACTORS

No contractor assistance has been used in the development and maintenance of the SEA NYMPH Life Cycle Cost Model. Contractors have provided limited assistance in the development of some cost inputs; but they do not have access to the output reports and they do not participate in running the model on the computer.

BUDGET COORDINATION

As was stated in the introduction, the project manager decided that a life cycle cost model of all anticipated Navy expenses would help to keep budget items from "falling through the cracks" during the hectic action of managing a concurrent development program. This problem was aggravated by the restrictions of five year defense budgeting, which meant that some funding for other projects had to be preempted; because there was not enough time to budget the money for SEA NYMPH. Finally, these problems were applied across many Navy offices that are responsible for financing portions of SEA NYMPH, as shown in Figure 2. The cost model provides a useful overview for project planning.

OPNAV RESOURCE SPONSOR	FUNDING CLAIMANT CONTACT	FUNDING TYPE	DESCRIPTION OF FUNDING COVERAGE
009G	PME107	RDT&E	Hardware & Software Devl
		OPN	Production Hardware
			Special Equipment
			Installation Support
			ILS Development
			SNMSC Start-up Material
		O&MN	Project Management
			Management Engr Support
			Software Maintenance
224	PME107	O&MN	Continuing SNMSC Operation
	ELEX460	OPN	Spares
043	SEA921	FMP	Backfit Installations
029	CNET	O&MN	Curriculum Maintenance
		MCON	Training Facility Construction
22	TYCOMs	O&MN	Overhauls
			Consumables
01	NAVPERS	MPN	Military Personnel Salaries
04	ELEX480	O&MN	General Purpose Test Equipment
	ELEX102	O&MN	SNMSC & Depot Staff Overhead
	NAVSUP054	O&MN	Spares Inventory Management

Figure 2. Navy Funding Flow for SEA NYMPH

SEA NYMPH COST MODEL

INTRODUCTION

The purpose of this section is to give a detailed description of how the SEA NYMPH LCC Model is organized from the viewpoint of a project manager who might wish to do something simmilar. The description will also serve to demonstrate the flexibility and detail of the LCC FLEX 9D Program.

COST BREAKDOWN STRUCTURE

The cost breakdown structure (CBS) for the SEA NYMPH E Suite is provided in Appendix A. The structure is divided into three phases of the equipment life cycle: Development, Acquisition, and Operation and Support. The report that records the cost breakdown structure is called the CS/EQ File. A typical example of the types of entries in this file is given in Figure 3.

CS121000	Project Office Salaries	1	6	4	4	1
EQ121000	DGPM(I);I,IY,Y					
CS211000	E Suite Acquisitions	1	1	3	3	1
EQ211000	SKPP(I),CEST,*,SKIP(I),+;I,IY,Y					
CS322100	Contractor Depot Repairs	3	16	4	4	1
EQ322100	NSI(I),OTS,QTYS(K),REFEE(I),*,*,*, 1,RSSS(K),-,*,1,DSCS(K),-,*,REFLRA(I), *,MTBFS(K),FRS(I),*,/:I,IY,Y,K,1,NKS					

Figure 3. Typical CS/EQ File Data

The Development Phase line items are 100000 series. The Acquisition Phase line items are 200000 series. The Operation and Support Phase line items are the 300000 series. The three line items are accompanied with their algorithm or cost equation. These equations are written using Reverse-Polish notation. The equation for Project Office Salaries is an example of a simple thru-put budget, which means it is supplied as input cost data and is not acted upon. It appears in the output reports just as it was given as input data. The only exception would be the introduction of compensation for inflation in the reports where inflated dollars are used. The cost factor (DGPM) is varied for each year (I) in the life cycle of the program.

The equation for E Suite Acquisitions demonstrates the use of several cost factors that vary annually with a cost factor having a fixed value. For example, SKPP represents the annual full scale production rate for E Suites. It is multiplied by a unit cost for E Suites,CEST. The multipication is indicated by the asterisk. In this equation, the costs of the full scale production E Suites are added to the costs of the limited production E Suites, as given by the cost factor SKIP(I). Good unit costs are not available during first phases of production, so those years are treated as thru-put.

CS121000	Project Office Salaries	1	6	4	4	1
EQ121000	DGPM(I);I,IY,Y					
CS211000	E Suite Acquisitions	1	1	3	3	1
EQ211000	SKPP(I),CEST,*,SKIP(I),+;I,IY,Y					
CS322100	Contractor Depot Repairs	3	16	4	4	1
EQ322100	NSI(I),OTS,QTYS(K),REFEE(I),*,*,*, 1,RSSS(K),-,*,1,DSCS(K),-,*,REFLRA(I), *,MTBFS(K),/;I,IY,Y,K,1,NKS					

Figure 3. Typical CS/EQ File Data, Repeated

The equation for Contractor Depot Repairs is the most complex expression used in the cost model. The basic computation is the the number of annual operating hours accumulated by all the systems in the Navy inventory. This is the product of the number of systems (NSI) and the average annual operating hours per system (OTS). This product is used for 500+ calculations for each year in the life cycle. The product is first multiplied to reflect the number of each type repairable in the system (QTYS). It may be a single power supply or a memory circuit card used in 53 locations. This product is multiplied by a repair fee that may be varied from year-to-year (REFEE). This result is then modified to remove all of the repairs at an intermediate maintenance activity (RSSS) and the percentage of each type repairable that is scrapped, lost or destroyed. This product is modified once more to reflect the portion of repair work being sent to the Navy depot each year. The result is divided by the mean time between failure. The residue from the 500+ such calculations represents the cost of contractor repairs for each year. Each of these values is inflated.

It can be seen that such an array of data can be manipulated by varying any of the parameters, such as the mean time between failure; in order to determine how the long term costs are affected. In fact, the data can be refined to the point of a long term depot repair cost for any individual repairable, a sort of mini cost model for such items as radio receivers, etc.

Returning to Figure 3, each cost line item has a series of numbers that provide codes for the calculations and the organizing of the various output reports. The number in the first column identifies the resource sponsor and the funding claimant. There are 9 active codes in the SEA NYMPH model. The resource sponsor is an office within the Chief of Naval Operations (OPNAV) responsible for requesting some portion of the SEA NYMPH costs in the annual DOD budget request to Congress. The funding claimant is an office in a subordinate Command that is responsible for spending the funds. The NAVELEX Acquisition Manager for SEA NYMPH, PME107-1, is a funding claimant. The Chief of Naval Education and Training, Naval Sea Systems Command, Commander Submarine Force Atlantic, Commander Submarine Force Pacific, and the Naval Supply Systems Command are other examples of funding claimants. It can be seen that these funding claimants represent the entire scope of costs incurred across all Naval Commands as a result of the SEA NYMPH Project for the duration of its 22 year life cycle.

The second column of numbers are codes for the 17 cost categories used in the Cost Model. A few examples of cost categories are hardware, software, management, supply support, etc. The cost categories appear in certain output reports that are oriented towards the cost analyst, who is interested in such matters as how much was spent on software development and how was the money spread across the development years.

The third column contains codes for funding types. There are a number of these. They represent restrictions on how the money can be spent, as well as the maximum length of time allotted by the Congress for completing the expenditure. For instance, O&MN funds are the only kind that can be used for Government salaries; and the funds must be spent in the fiscal year they are authorized by the Congress. RDT&E funds are used for research and development. They have a more liberal time frame for expenditures. The funding types must be carefully assigned to each line item in the cost model, so that they are in accordance with spending restrictions. The fourth column has the inflation code associated with each funding type in the third column. The last column contains a service code.

COST FACTOR VALUES

The cost breakdown structure is the design of the life cycle cost model. There are several other files in the LCC FLEX 9D Program that are based on data from the cost breakdown structure. The cost factors selected for the cost equations are also listed in the NV File. Figure 4 illustrates a portion of a typical

NV File. The term NV stands for "new value" which reflects how the LCC FLEX 9D Program was designed. Every run of the cost model is considered to be a new cost model with new values; and, in fact, there is some potential in the model for running two different cost models back-to-back. The NV File contains a listing of all the cost factors created for the equations in the cost breakdown structure.

There are three types of NV File entries. The first set of file entries are cost factors that have constant values. The ratio of unpackaged-spares-weight to packaged-spares-weight is typical of the values. The second set of cost factors are those that vary with each year in the life cycle. They all have a notation that ends with (Y). The third set of cost factors are those that vary with the individual repairables in the system. These cost factors have notations that end with (NKS). As an example, the cost factor MTBFS(NKS) in the SEA NYMPH cost model has over 500 values, one for each repairable circuit card, power supply, RF module, etc. in the system. Everytime a computer run is made, the cost factor MTBFS is used to make 500+ calculations of depot repair costs for each of the 22 years in the life cycle. Each is then multiplied by the applicable inflation factor for that year. There are 9 of these (NKS) cost factors with 500+ values, in the SEA NYMPH E Suite Cost Model.

```
NV   CEST        180300.

NV   SKPP(Y)     5*0,1,3,5,5,7,5,3,1,9*0.

NV   MTBFS(NKS)  26300,109100,20500,7300,193500,139950.
```

Figure 4. Typical NV File Data

In the above example, the unit cost of the E Suite (CEST) is $180300. There are 22 values for the full scale production of the E Suites (SKPP); one value for each year of the life cycle. There is no full scale producion in the first 5 years or the last 9. There are 6 repairable types of modules for which the predicted mean time between failure, in hours, is given for the cost factor MTBFS(NKS). In this example, there are only 6 repairables in the system.

COST FACTOR DESCRIPTIONS

A second file within the LCC FLEX 9D Model that is derived from the cost breakdown structure is the cost factor dictionary, which is denoted as the DS File. A sample of the SEA NYMPH DS File is given in Figure 5. The cost breakdown structure number given with the description identifies the first place in the cost model where the cost factor is used. The derivation of the cost factor's value, or values, will be found within the derivation sheet associated with that cost line.

DS	CUYK	Unit Cost of AN/UYK-20 Computer	212000
DS	DRADAT	Manufacturer's Drafting and Data Costs	253200
DS	NSI	E Suite Inventory	321500,321600,321700,322100

Figure 5. Typical DS File Data

The interrelationships between the above-mentioned data files is further amplified by two examples of cost line item construction in Appendix D.

NAMELIST DATA

The Namelist Data File provides instructions to the computer concerning the type of output reports desired -whether they are to be inflated, what the inflation rates will be, and if sensitivity analyses are required. The file identifies the output reports by the control card (CN) data. The CN card lists all of the possible output report formats that may be selected for each run. These report formats listed in Figure 6 and illustrated in Appendix C.

Another feature of this file is the option of making two runs back-to-back, automatically, with two sets of data inputs. This feature has been used in SEA NYMPH to generate a total life cycle cost report and then a secondary report for a selected subset of the total. The subset is selected by establishing an exclusion listing of all line items in the cost model that are not to be included in the subset. For instance, if the second run was to be for all production and operational phase costs, the development phase costs would be listed in the exclusion file. In this case, CBS 100000 Research and Development Phase Costs would be listed. The computer would automatically exclude this line and all lines indentured below it, such as CBS110000, CBS111000, etc.

It should be noted that the use of the sensitivity analysis feature in the LCC FLEX 9D Program requires some care. The sensitivity analysis feature allows a range of incremental changes to a cost factor with the computer calculating the resultant life cycle cost for each increment. This allows the analyst to identify a cost-driver, that is, a cost for which a relatively small change generates a relatively large change in life cycle cost. There are three types of cost factors in the model: those with a fixed value, those which vary by year, and those which vary by repairable item. If one elects to do a sensitivity analysis on a cost factor that has annual variations (22 years for instance) inordinate amounts of computer time will be consumed as total life cycle costs are calculated for each of ten increments for each of 22 years.

SUMMARY BY COST CATEGORY
SUMMARY BY LIFE CYCLE PHASE
COST BREAKDOWN STRUCTURE BY YEAR
COST BREAKDOWN TOTALS WITH PERCENTAGES
GENERAL REPORT OF TOTALS BY FUNDING TYPE
ANNUAL TOTAL COST BY FUNDING TYPE
ANNUAL TOTAL COST BY COST CATEGORY
SENSITIVITY ANALYSIS
LCC PHASE COSTS BY FUNDING CLAIMANT
FUNDING BY FUNDING CLAIMANT
ANNUAL FUNDING BY TYPE FOR CLAIMANT
ANNUAL COST SUMMARY BY CLAIMANT

Figure 6. Types of Output Reports

BASE YEAR AND INFLATION

The LCC FLEX 9D program assumes that the data set given in the NV FILE is in terms of constant dollars. Constant dollars imply the present value of money, with the present value being a baseline from which future inflation is measured. The baseline year is selected by the cost analysis and is an input to the Namelist Data File. The base year can be any year in the length of the life cycle that has been selected. Base year is denoted as BY. The computer will inflate all costs starting in the year following the base year. Each year the base year is normally advanced and the inflation rates are revised. There are different inflation rates for O&MN, OPN, and RDT&E funding in the model. They are changed when the revisions to the Department of Defense indices are issued for budget preparations.

COST MODEL ANALYSES

INTRODUCTION

The purpose of this section is to describe the various analyses that have been done with the SEA NYMPH cost model over the past several years. This work serves as a practical example of how the element of cost is being used to impact the planning within the specifics of an acquisition program. It shows that even after the major decisions of hardware design have been made, there are areas where practical tradeoffs can be made, utilizing an LCC model.

SYSTEMS ENGINEERING FUNCTION

The analytical aspects of life cycle cost and design-to-cost work are a systems engineering function; not a budgetary or a project management function. MIL-STD-881A, Work Breakdown Structures For Defense Material Items, which is the basic guide for planning contractor work breakdown structures, contains a clear assignment of the cost analysis role under the system engineering umbrella. It is the:"logistics engineering effort to define, optimize and integrate the logistics support considerations into the mainstream engineering effort to insure the development of a supportable and cost effective weapon system". More specifically, it is value engineering within the system definition function and it is life cycle cost and tradeoff analysis within the support synthesis

CONTRACTOR VS NAVY DEPOT

The SEA NYMPH Cost Model contains separate line items for both the Contractor and Navy depot repairs. Equations for these two line items were discussed earlier. It is possible to vary the percentage of repair work going to the contractor and Navy depots through the cost factor REFLRA(I). The equation was set up this way so that the gradual turnover of work to the Navy could be simulated: 95% for 3 years, 80% for 2 years,etc. REFLRA(I) can also be changed to give 99.9% to either Navy or contractor for all of the repair years. This made it possible to compare the two alternatives and to measure the possible savings if the Navy depot was used as much as possible. As the contractor's fee was varied, a large advantage emerged in favor of the Navy depot. To verify this, another operating and support cost model was prepared for a direction finder. This system has a different manufacturer; but its modules are repaired at the same Navy depot. In this case, the

costs of work at the Navy depot were about half the costs of contractor depot repair. These two cost models are in general agreement that Navy depot repairs can be much cheaper; but it should be noted that actual savings will vary between Navy depots just as they do among contractors.

It is important to realize that these cost findings were based on inherent design characteristics of the equipments, as reflected by predicted failure rates, and actual factory repair records from each of the contractors involved.

ESM COST DRIVER

The magnitude of SEA NYMPH depot repair costs that emerged from the analysis work was not readily accepted. The total cost of these repairs, inflated over the operational life cycle, was half the total cost of the E Suite systems themselves. A review of the actual depot repairs by the contractors showed that the repair costs could be separated into categories of repairables, which in turn allowed further refinement of the cost data. Temporary data sets were created from the baseline using the IBM 3431 at the Naval Electronic Systems Engineering Center, San Diego. The 9 data arrays for the 500+ repairables (MTBFS is one of these) were modified to isolate repairable categories; hence the costs for the categories. Figure 7 summarizes what was found.

Total Life Cycle Depot Repair Costs		100.0 %
54	RF Module Types	64.9 %
372	Circuit Card Types	21.4 %
48	Analog Modules	8.3 %
32	Power Supplies	2.6 %
1	Disc	0.9 %
Costs Not Isolated		1.9 %

Figure 7. SEA NYMPH Depot Repair Cost Projection

There was timely confirmation in the form of a projection for the interim repair depot over the first three years of operation. Out of the 178 repairables built by the contractor, 12 RF modules accounted for 63.6% of the total bill. Similar results were found using the operating and support cost model for the radio direction finder. The depot repair of RF modules appears to be a cost driver for submarine radio systems in general and for SEA NYMPH in particular.

DIVIDING RF MODULES

The RF modules that are so expensive to repair are usually metal containers of various sizes and shapes that contain smaller modules or circuit boards. In some cases, these are designed so that they might be made into repairables. This can often allow the large failure rate to be isolated to a smaller, and perhaps less expensive unit. For instance, Figure 8 shows a hypothetical radio receiver and what it might contain.

Part Number	Description	Quantity In Rcvr	Failure Rate	Unit Price
800-123906G1	VLF Radio Receiver		505	39000
810-123911-1	RF Receiver CCA	1	249	5000
810-123913-2	RF Oscillator	1	189	2300
810-123914-1	Power Supply	1	43	1700
810-123988-A	RFI Filter Assembly	6	23	563
810-123966G1	Module.Chassis Parts	1	8	1480
etc				

Figure 8. Hypothetical VLF Receiver

In Figure 8, the failure rates are typical examples of how the selective sparing of subassemblies can greatly reduce the cost of spares and depot maintenance. The combined failure rate of the first two items in the receiver is 438 or 87%. In other words, 87 percent of all failures could be covered with the sparing of two subassemblies, at 19 percent of the cost of the receiver. This is the kind of tradeoff that value engineering should be making early in the hardware development.

Another way of considering this matter has to do with the cost of spares. If the Government spares only at the VLF Radio Receiver level, then for every failure of the $5000 RF Receiver Circuit Card in Figure 8, the Government is replacing an entire receiver that costs $39000. For every failure of the $2300 RF Oscillator, the Government is replacing the entire receiver again. For 87% of the failures the rest of the receiver consisting power supply, chassis, RFI Filter Assembly,etc is just baggage.

There are some RF modules within the SEA NYMPH E Suite that are candidates for division for the sake of long term economy. The method of analysis has been to isolate the data for an individual module, such as a receiver, in each of the 9 large arrays. The data is replaced with a temporary subset of data representing the parts of the receiver. In the case of the hypothetical VLF Receiver in Figure 8, the RF Circuit Card, the RF Oscillator, and the Power Supply might be the subset. The cost model is then run with this temporary data subset to determine how much change occurs in total life cycle cost.

It must be pointed out that the cost of hardware redesign and the impacts on configuration control make this a difficult undertaking for existing equipment. There are several worthwhile opportunities within SEA NYMPH nonetheless and analysis work has been done on those RF modules for which the proper data was available for the subassemblies.

RELIABILITY IMPROVEMENTS

Subdividing the hardware is one approach to reducing the life cycle costs associated with the depot repairs. Another approach is to address the inherent reliability of the RF modules themselves. It is the predicted failure rate that sends the modules into the depot and it is possible that reliability improvements might pay for themselves in reduced repair costs, while improving system performance in the Fleet at the same time. The method used to explore these possibilities was to, again, create a temporary data set from the baseline, modify the MTBF value for a single RF module and then run the temporary data set for a new total life cycle cost. It was found that for some RF modules a relatively small improvement in reliability could save millions over the life cycle of the SEA NYMPH System. This has resulted in establishing a new task at NUSC to explore methods of improving reliabilities.

SPECIAL LCC APPLICATIONS

INTRODUCTION

The purpose of this section is to discuss some of the special life cycle cost applications for the SEA NYMPH Project that may have relevence on other programs.

LEARNING FACTORS

The learning factor is a measure of the reduction in effort required to accomplish the same task when it is repeated many times. Learning factors should be applied to acquisition costs where there is a large segment of recurring costs during the production run. The factors compensate for reduced time by lowering production costs. This becomes progressively important as the magnitude of the production run increases. There is a cutoff point for the use of learning factors below which its usefulness can be questioned. Just where the cutoff is remains a matter of interpretation. However, the SEA NYMPH Project involves only 43 systems, which is small. It was also a concurrent development in which the development and production were occurring simultaneously in some areas, such that production stability was delayed. The complexity of the situation and the time constraints obliged the Project Office to reduce the influence of learning factors.

HISTORICAL COSTS

There is a problem with using the existing Government cost data for establishing historical costs. The Government budgets an amount of funding for a contract on the basis of fiscal years, which is how the money initially shows up in a cost model. The contractor does not spend all the money in the same fiscal year. His rate of expenditure can be seen in the cost performance reports (CPRs). It is difficult to correlate what was budgeted by the Navy with the expenditures reported by the contractor, particularly if the contract instrument is frequently modified, such that the total amount fluctuates up and down. The format used in Navy funding documents, such as the P-1 sheets, is not compatible with the format of the CPRs. The difficulty becomes pronounced when the Project Office introduces unit costs and a schedule for future acquisitions. The cost analyst must find a way of combining the unpredictable historical costs reported in the CPRs with the fixed unit cost schedule of the future

within the same cost line item. The equation for E Suite Acquisitions, in Figure 3, reflects the combination of historical costs and budgetary costs within the same algorithm. This is also a good illustration of how the flexibility of the LCC FLEX 9D will allow the generation of an equation that is tailored to the situation, rather than trying to tailor the situation to a rigid cost model format.

DEPOT COST FACTORS

As was mentioned earlier, the depot repair costs in the SEA NYMPH cost analyses are actuals based on contractor and Navy depot repair data. The contractor data came from visits to the local Defense Logistics Agency, Contract Administration offices. These offices administer depot repair contracts. Their files normally contain the contractor's bid and the negotiated payment for each repair. The information may be made available on a need-to-know basis with concurrence of the cognizant project office. The data are detailed enough to isolate types of repairables and develop average repair costs that are unique to each contractor. This information can, in turn, be introduced into the LCC FLEX 9D cost model data arrays, such that for each repairable there is a set of cost factors based on each manufacturer's past performance.

COST DISTRIBUTION BY PHASE

There has been an emphasis in life cycle cost literature on the excessive costs of the operations and support, or O&S, phase of the system life cycle. This emphasis reflects the avionics orientation of life cycle cost from earlier years. In some cases, the O&S costs have been reported to be as high as 65% of the total life cycle. Submarine electronics equipment does not suffer from the operating expenses of avionics systems. Figure 9 summarizes the distribution of cost by phase, as it has been calculated for several years, using constant dollars.

	Oct 1978	Apr 1979	Mar 1980	Oct 1980
DEVELOPMENT PHASE	6.3%	6.8%	6.2%	6.8%
ACQUISITION PHASE	53.0%	56.7%	57.3%	61.4%
OPS & SUPPORT PHASE	40.7%	36.4%	36.5%	31.8%

Figure 9. SEA NYMPH LCC Cost Distribution

NAVY DEPOT OVERHEAD

Most of the SEA NYMPH repairables will eventually return to the depot at the Naval Electronic Systems Engineering Center, San Diego. This depot will add SEA NYMPH repairables to the approximately 2000 other types of repairables from other systems that are already being serviced. The repair work at this depot for any particular system is erratic. That is to say, it may vary from 2% of the total workload in one month to 12% the next, or 38%. This makes it difficult to assign overhead charges to any specific system.

The approach taken was to tie an hourly surcharge into the annual calculations of turn-ins for each of the 500+ types. (See the discussion of EQ322100 in Figure 3). The surcharge was determined by adding the annual administrative and the annual utility costs. This sum was divided by the number of technicians that are working at the depot (120) and then by the annual number of hours each technician works (2080). The resulting surcharge is what must be added to each hour of repair work to cover the overhead. This means the SEA NYMPH Cost Model has an hourly surcharge for every repairable reaching the depot each year, regardless of when when it is fixed.

However, the number of labor hours required to repair an RF module is different from what is required for the typical circuit card. This is resolved by dividing the depot repairs into several categories of repairables and using labor times tailored to each type. For instance, 4 hours is allotted to circuit cards repairs. This allows the hourly facility charge to be applied according to the amount of time each type of repairable requires.

SEA NYMPH MISSION SUPPORT COMPLEX

The SEA NYMPH Mission Support Complex (SNMSC) is part of the Naval Electronic Systems Engineering Center, San Diego. The SNMSC is significant, because of its role as a Field Maintenance Agent (FMA) for a large electronics system that is computer-controlled. The SEA NYMPH Cost Breakdown Structure in Appendix A has a section in the Acquisition Phase and the Operational Phase for SNMSC. The line items are in effect a summary description of how SNMSC is organized and what special cost categories are introduced by a computer-controlled system.

UNCERTAINTY MEASUREMENT

The less that is known about a planned new equipment, the greater the element of uncertainty in the cost projections. In the case of Sea Nymph, the life cycle cost model was introduced while the engineering development model (EDM) was being built. A great deal was known and hence the introduction of uncertainty into this particular cost model did not appear to serve a useful function. As has been stated earlier, the parametric aspects of cost modeling were not emphasized, and that is where measuring the degree of uncertainty becomes important.

REPROVISIONING COSTS

When the SEA NYMPH LCC model was reviewed by independent consultants, one of the recommendations was to increase the discard rates used to calculate reprovisioning costs from .5% to 2-3%. As can be seen in Figure 10, this resulted in a dramatic increase in life cycle costs in January, 1979. Approximately one year later, the costs were back down to approximately where they had been.

LCC Run Date	% of Total LCC in Constant Dollars
13 October 78	1.3 %
27 January 79	4.3 %
15 June 79	3.8 %
25 March 80	1.6 %
24 March 81	1.5 %

Figure 10. Reprovisioning LCC Costs

This reduction was made possible by incorporating new data into the assumptions for the reprovisioning: (a) The SSN637 attack submarines carrying SEA NYMPH would reach the end of their hull life beginning in Year 16. Their equipment would be cannibalized for replacement spares; therefore no new spares would have to be bought after Year 16 in the life cycle. (b) Personnel who replace depot repairable items on the platform are accountable for loss of high cost items; and therefore the higher the value the less likely it is to be lost. A bias was introduced into the the calculations to reflect this assumption.

EVALUATING PROCUREMENT OPTIONS

In the Fall of 1980, the SEA NYMPH life cycle cost model was used to evaluate an array of 5 procurement options. The procurement plan at that time called from completion of the production buys in FY84. The options ranged from continuing this plan to buying all the systems by the end of FY82. One of the cost factors used in the cost model equations is SKPP(I), which is the E Suite procurement rate for each year. By varying SKLPP(I) to fit each of the procurement options, it was possible to make an approximate measurement of how much inflation could be avoided with an early buy-out of the systems and their spares. Accelerating the buyout from FY84 to FY82 saved the equivalent cost of three additional systems.

APPENDIX A

SEA NYMPH COST BREAKDOWN STRUCTURE

SEA NYMPH COST BREAKDOWN STRUCTURE

000000	Total Life Cycle	
100000	Research and Development Phase	
110000	Contractor Payments	
111000	Hardware Development	RDT&E
112000	Software Development	RDT&E
113000	Integration & Interface	RDT&E
114000	Development Test & Evaluation	RDT&E
115000	Support	RDT&E
116000	Data	RDT&E
117000	Contractor Management	RDT&E
118000	Other Costs & Fees	RDT&E
119000	Definition Phase	RDT&E
120000	Government Expenses	
121000	Project Office Management	O&MN
122000	Project Office Engineering Support	O&MN
123000	GFE For Development	RDT&E
200000	Acquisition Phase	
210000	Hardware Acquisition	
211000	E Suite	OPN
212000	AN/UYK-20 Computers	OPN
213000	SRL-2289	OPN
214000	HP 0-1695	OPN
220000	Special Hardware Acquisitions	OPN
230000	Initial Support Acquisitions	
231000	Supply Support	
231110	E Suite OBRP	OPN
231120	SRL-2289 OBRP	OPN
231130	Other OBRP	OPN
231140	System Stock	OPN
231150	Installation Checkout	OPN
231200	Early Supply Support Planning	O&MN
232000	Documentation	
232100	Operator Manuals	OPN
232200	Maintenance Manuals	OPN
232300	Planned Maintenance Procedures	OPN
232400	Engineering Drawings	OPN
232500	Maintenance & System Log Tapes	OPN
232600	IMA Documentation	OPN
232700	Depot Documentation	OPN
233000	Training	
233100	Factory Training Materials	OPN
233200	Factory Training Fees	OPN
233300	MIL-SPEC Training Curriculum	OPN
233400	MIL-SPEC Training Fees	OPN
233500	Prefaulted Training Modules	OPN

SEA NYMPH COST BREAKDOWN STRUCTURE

234000	NESEC San Diego	
234100	Production Support	
234110	Shipyard Installation Support	O&MN
234120	Test & Evaluation Support	O&MN
234130	Initial Operations Support	O&MN
234140	Logistic Support	O&MN
234200	SNMSC	
234210	FMA Start-Up	O&MN
234220	TSSC Start-Up	O&MN
234230	SNMSC Facilities	O&MN
234300	Depot	
234310	Start-Up	O&MN
234320	Facilities	O&MN
235000	Support & Test Equipment	
235100	Platform GPETE	OPN
235200	IMA GPETE	OPN
235300	Depot GPETE	OPN
235400	SPETE,Test Systems,Support Equip	OPN
235500	Installation Checkout GPETE	OPN
235600	Training GPETE	OPN
235700	System Groom & Cal GPETE	OPN
235800	SNMSC GPETE	OPN
236000	Facilities	
236100	Training Sites	MCON
236200	IMA	OTHR
237000	Transportation	O&MN
238000	Installations	
238100	Retrofits To SSN637 Platforms	O&MN
238200	Shore Sites	O&MN
238300	Installation Planning	O&MN
240000	Government Expenses	
241000	Project Office Management	O&MN
242000	Project Office Engineering Support	O&MN
250000	Contractor Production Support	
251000	Data	OPN
252000	Engineering	
252100	R&M	OPN
252200	ILS	OPN
252300	Configuration	OPN
252400	Field	O&MN
252500	Installation of Retrofits	O&MN
252600	Systems	OPN
253000	Manufacturing	OPN
254000	Testing & Integration	OPN
255000	Software Maintenance	O&MN
256000	Management	OPN
257000	Profit/Fee	OPN
258000	ECPs	O&MN
259000	EDM Refurbishment	OPN

SEA NYMPH COST BREAKDOWN STRUCTURE

300000	Operation and Support Phase	
310000	Operation	
311000	Operator Salaries	MPN
312000	Material Consumption	O&MN
313000	Special Operating Costs	O&MN
320000	Support	
321000	Direct Maintenance	
321100	SSN637 Platform Maintainer Salaries	MPN
321200	IMA Maintainer Salaries	MPN
321300	MOTU Military Salaries	MPN
321400	MOTU Contractor Salaries	O&MN
321500	NESEC SD Depot Labor	O&MN
321600	NESEC SD Depot Material	O&MN
321700	Second Destination Charges	O&MN
321800	Contractor Depot Repairs	O&MN
322000	E Suite Overhauls	O&MN
323000	Other Maintenance Requirements	O&MN
324000	SNMSC	
324100	Management	O&MN
324200	Field Maintenance Agent(FMA)	
324210	Software Modifications	O&MN
324220	Hardware Modifications	O&MN
324230	Product Improvement Analysis	O&MN
324240	Fleet Assistance	O&MN
324250	Configuration Control	
324251	Change & ID Control	O&MN
324252	Documentation Control	O&MN
324300	Tactical Systems Support Complex(TSSC)	
324310	TSSC Staff	O&MN
324320	TSSC Systems Software Maintenance	O&MN
324330	E Suite Scenario Evaluations	O&MN
324340	E Suite System Tape Builds	O&MN
324350	E Suite System Tape Support	O&MN
325000	Facilities Operation Cost	
325100	SNMSC	O&MN
325200	Depot	O&MN
325300	Shore IMAs	O&MN
325400	Training Sites	O&MN
326000	ECPs	O&MN
327000	Supply Support	
327100	Reprovisioning of Repairables	O&MN
327200	Inventory Management	O&MN
328000	Training	
328100	Platform Maintainer Salaries	MPN
328200	Platform Operator Salaries	MPN
328300	Instructor Salaries	MPN
328400	Civ Maintenance Engr TDY	O&MN
328500	Curriculum Maintenance	O&MN
329000	Tools & Test Equipment Maintenance	O&MN
330000	Project Management	O&MN

SEA NYMPH COST BREAKDOWN STRUCTURE

328300	Instructor Salaries	MPN
328400	Civilian Maintenance Engr TDY	O&MN
328500	Platform Officer (EMO) TDY	O&MN
328600	Curriculum Maintenance	O&MN
329000	Tools & Test Equipment Maintenance	O&MN
330000	Project Management O&S Phase	O&MN

APPENDIX B

A SAMPLE COST MODEL BOOK

A SAMPLE COST MODEL BOOK

SECTION ONE

CORRESPONDENCE

APPLICABLE INSTRUCTIONS
OMB Circular A-109,"Major System Acquisitions"
DOD Directive 5000.1,"Major System Acquisitions"
DOD Directive 5000.2,"Major System Acquisition Process"
OPNAVINST 4720.9d,"Approval of Equipments For Service Use"
NAVMATINST 4200.50A,"Contractor Support Services"

HOW TO USE THE COST MODEL
Cost Model Description
Sample Questions on Finding Data

HISTORICAL
Semi-annual Constant Dollar Cost For Life Cycle

SECTION TWO

CS/EQ DATA FILE

DS FILE DICTIONARY OF COST FACTORS

NV FILE

CURRENT INFLATION RATES

TOTAL LCC REPORTS

SUBSET LCC REPORTS

SECTION THREE

DEVELOPMENT PHASE DERIVATION SHEETS

ACQUISITION PHASE DERIVATION SHEETS

OPERATIONAL PHASE DERIVATION SHEETS

APPENDIX C

COST MODEL REPORT FORMATS

COST MODEL REPORT FORMATS

HYBRID P-1 SHEET FOR OPN OR O&MN

Appropriation: OPN Resource Sponsor: OP-XXX	PROGRAM COST BREAKDOWN (LCC Fanout By Year)							Date: 1981
Budget activity 2 COMM & ELECTRNIC EQ	P-1 Item Nomenclature AN/WXX-5(B)							Subhead 52TF
COST MODEL NUMBER	COST MODEL DESCRIPTION	Constant KDollars FY79	Constant KDollars FY80	Base Yr FY81	--> Inflated KDollars FY82	Inflated KDollars FY83	Inflated KDollars FY84	
	TF001 LCC FANOUT							
211000	Production Hardware	1800	2305	2416	2559	1490	609	
232100	Operator & Unit Manuals	250	118					
232300	MRCs,Preliminary	58						
232400	Engineering Drawings	300	475					
233100	Factory Training Fees	119						
235120	Special Test Equipment	49	40					
237300	Installation Mockups	75	35					
	TF001 TOTALS	2651	2973	2416	2559	1490	609	
	TF002 LCC FANOUT							
212000	AN/UYK-82 Computer	180	210	228	230	150	100	
235130	Math Pak Kits	18	21	23	23	15	10	
	TF002 TOTALS	198	231	251	253	165	110	
	TF003 LCC FANOUT							
213000	Depot Test Station	251	23					
	TF003 TOTALS	251	23					
	GRAND TOTALS	3100	3227	2667	2812	1655	719	

COST MODEL BREAKDOWN BY YEAR

TOTAL LIFE CYCLE COST

COST BREAKDOWN STRUCTURE NUM	COST BREAKDOWN STRUCTURE ELEMENT	COST FOR YEAR 1	2	3	4	5
000000	Total Life Cycle Cost					
100000	Rsrch & Devlpmnt Costs					
110000	Contractor Payments	2900	2800	1200	0	0
120000	Government Expenses	250	280	230	0	0
200000	Investment Costs					
211000	Production Hardware	0	0	1800	2305	2416
212000	AN/UYK-82 Computer	0	0	180	210	228
ETC						

COST MODEL REPORT FORMATS

ANNUAL SUMMARY BY COST CATEGORY

COSTS IN THOUSANDS — BASE YEAR = 3 — THIS REPORT INFLATED $

COST CATEGORIES

YEAR	HARDWARE	SOFTWARE	TESTING	PROD SUPPORT	DATA	ETC	TOTAL
1	1403	320	163	0	112		
2	1109	440	230	0	190		
3	1980	420	112	139	90		
4	etc						
5							
6							
7							
8							
9							
etc							

SUMMARY BY LIFE CYCLE PHASE

COSTS IN THOUSANDS — BASE YEAR=3 — THIS REPORT INFLATED $

COST CATEGORY	ELEMENT OF DEVELOPMENT	ELEMENT OF INVESTMENT	ELEMENT OF O & S	TOTALS
HARDWARE	2512	14180	0	16692
% COST CATGRY	15.0	85.0	0.0	100.0
% COST ELEMNT	56.7	91.2	0.0	41.4
SOFTWARE	1180	etc	0	1180+
% COST CATGRY	etc			
% COST ELEMNT				
TESTING	505	etc	0	505+
% COST CATGRY	etc			
% COST ELEMNY				
ETC				

COST MODEL REPORT FORMATS

COST BREAKDOWN BY PERCENTAGES

COSTS IN THOUSANDS — BASE YEAR=3 THIS REPORT INFLATED $

COST BREAKDOWN STRUCTURE NUMBER	COST BREAKDOWN STRUCTURE ELEMENT	TOTAL COST	PERCENT OF TOTAL LIFE CYCLE COST
000000	TOTAL LIFE CYCLE COST	13590	100.0
100000	RESEARCH & DEVELOPMENT	940	6.9
110000	CONTRACTOR PAYMENTS	580	4.3
111000	HARDWARE DEVELOPMENT	230	1.8
112000	SOFTWARE DEVELOPMENT	130	.9
113000	INTEG & INTERFACE	40	.3
114000	DEVL TEST & INTEG	20	.1
115000	SUPPORT	30	.2
116000	DATA	20	.1
117000	MANAGEMENT	80	.7
118000	DEFINITION & OTHER	30	.2
120000	GOVERNMENT EXPENSES	360	2.6
121000	PROJ OFFICE MGMT	10	.1
122000	PROJ OFFICE ENGR SUPPORT	120	.7
123000	PROJ OFFICE MIL PERSONNEL	04	.0
124000	SPECIAL TEST SYSTEMS	230	1.8
200000	INVESTMENT	ETC	

GENERAL FUNDING REPORT

COSTS IN THOUSANDS — BASE YEAR=3 THIS REPORT INFLATED $

COST BREAKDOWN STRUCTURE NUMBER	COST BREAKDOWN STRUCTURE ELEMENT	TOTALS BY GENERAL FUNDING TYPE: RDT&E	OPN	O&MN	MPN	OTHER
111000	HARDWARE DEVELOPMENT	230				
112000	SOFTWARE DEVELOPMENT	130				
113000	INTEG & INTERFACE	40				
114000	DEVL TEST & INTEG	20				
115000	SUPPORT	30				
116000	DATA	20				
117000	MANAGEMENT	80				
118000	DEFINITION & OTHER	30				
121000	PROJ OFFICE MANAGEMENT			10		
122000	PROJ OFFICE ENGR SUPPT			120		
123000	PROJ OFFICE MIL PERS				04	
211000	PRODUCTION HARDWARE		11178			
ETC						

COST MODEL REPORT FORMATS

ANNUAL TOTAL BY FUNDING TYPE

COSTS IN THOUSANDS — BASE YEAR=3 THIS REPORT INFLATED $

YEAR	R&D	HARDWARE OPN	OTHER OPN	O&MN	MPN	OTHER	TOTAL
1							
2							
3							
4							
5							
ETC							

ANNUAL TOTAL BY COST CATEGORY

COSTS IN THOUSANDS — BASE YEAR=3 THIS REPORT INFLATED $

YEAR	HARDWARE	SOFTWARE	DOCUMENTATION	TRANSPORTATION	FACILITIES ETC
1					
2					
3					
4					
5					
ETC					

SENSITIVITY ANALYSIS

COSTS IN THOUSANDS — BASE YEAR=3 THIS REPORT INFLATED $

SENSITIVITY ANALYSIS

SENSITIZED VARIABLE:
CU = UNIT PRICE CONTRACTOR'S EQUIPMENT
BASE VALUE OF $50000

VALUE	DEVL PHASE		INVESTMENT PHASE		O & S PHASE		TOTALS	
50000	3960000		11617925		30883107		46461033	
25000	3960000	0%	9117925	-21.5%	30883107	0%	43961033	-5.4%
35000	3960000	0%	10117925	-12.9%	30883107	0%	44961033	-3.2%
65000	3960000	0%	13117925	+12.9%	30883107	0%	47961033	+3.2%
75000	3960000	0%	14117925	+21.5%	30883107	0%	48961033	+5.4%

(This example from Life Cycle Cost Guide For Equipment Analysis, by Naval Weapons Engineering Support Activity, January, 1977)

APPENDIX D

COST LINE ITEM CONSTRUCTION

TYPICAL ANALYTIC LINE ITEM CONSTRUCTION

CBS LINE ITEM
The following steps are required to construct this analytic line item

321500 Depot Repair Costs

COST MODEL BOOK DERIVATION SHEET
List the costs covered, how funding estimates were made, assumptions, the resource sponsor, funding claimant, type funding, correspondence and the applicable Navy instructions. Update sheet as needed without destroying historical information

DS PROGRAM FILE INPUT
A data input to the computer. It provides the dictionary definition for each cost factor.

```
DS MTBF(NKS) = mean time between fail
               ure for each repairable
               in thousands of hours
DS SOT       = annual system operatine
               time in hrs
DS QTY(K)    = quantity of each type
               repairable in the system
DS REFEE     = average repair fee for
               depot repairable items
```

CS/EQ PROGRAM FILE INPUT
CS Line: a data input to computer. Provides cost title, funding code, sponsor-claimant code, cost category code, inflation category code.

```
CS321500 Depot Repairs   3 5 3 13 2
```

EQ Line: a data input to computer. Provides listing of cost factors to be used in calculating annual costs for this line item

```
EQ321500 MTBF(K),SOT,QTY(K),REFEE,*,
         *,*;I,IY,Y,K,1,NKS
```

NV PROGRAM FILE
A data input to computer. It provides non-varying, varying by year(I) and varying by repairable item(K) according to cost factor requirements.

```
NV MTBF(NKS):12500,2230,16700. (note)
NV SOT      :6000.(non-varying)
NV QTY(K)   :3,21,53.(Values for 3)
NV REFEE    :750.(non-varying)
```

(note) example uses three repairables

TYPICAL BUDGETARY LINE ITEM CONSTRUCTION

CBS LINE ITEM

The follwoing steps are required to construct this budgetary line item

---

221000 Hardware Acquisition

COST MODEL BOOK DERIVATION SHEET

List the costs covered, how funding estimates were made, assumptions, the resource sponsor, funding claimant, type funding, correspondence and the applicable Navy instructions. Update the sheet as needed without destroying historical information.

DS PROGRAM FILE INPUT

A data input to the computer. It provides the dictionary definition for each cost factor.

DS HACQ(I) Hardware Acquisition,$/Yr

CS/EQ PROGRAM FILE INPUT

CS Line: a data input to computer. Provides cost title, funding code, sponsor-claimant code, cost category code, inflation category code.

CS221000 Hardware Acq 16 9 7 3 3

EQ Line: a data input to computer. Provides listing of cost factors to be used in calculating annual costs for this line item.

EQ221000 HACQ(I);I,IY,Y

NV PROGRAM FILE

A data input to computer. Provides a listing of cost values for the cost factor by budget year. This sample is for a 10 year life cycle.

NV HACQ(Y) 0,0,0,20000,50000,180000,
80000,50000,0.

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